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LEVEL II

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EVALUATION OF DUAL-TEXTURE GRADIENT CAMOUFLAGE PATTERN

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Recent trends in tactical doctrine for United States ground forces suggest the inevitability of "fighting outnumbered" in the unitial stages of the next war - a position of inferiority which increases as never before the need for the most effective training, doctrine and equipment. The battlefield of the 1980's will present new challenges for ground forces, and require a variety of passive and active counter-surveillance measures to allow tactical units to operate in an environment which combines not only very high weapon lethality but also improved target acquisition means. Maintaining favorable exchange ratios -- a fundamental supposition of the Active Defense -- will require the doctrine, training and hardware to counteract precision-guided munitions, protect headquarters units vital to battlefield control and communications, and insure initial advantage in tactical engagements. These advantages are unattainable without extremely effective countersurveillance measures.

Present measures include improved paints and coatings, lightweight multipurpose nets, thermal image suppression devices, and a standard concealment pattern. This pattern has been in use for several years, and has been applied successfully in a variety of units. The US Army (MERADCOM) pattern is a four-color standard pattern system which is designed to be supplemented with natural and artificial garnish for maximum concealment effect. This presents special problems in the Active Defense tactical scheme.

Nets and garnish-- including natural vegetation -- require set-up times which are generally proportional to the size and signature of the vehicle being camouflaged. Certain critical systems, however -- notably the XM1, MICV and Improved TOW Vehicle -- require not only the most astute camouflage measures, but also must meet the requirement of rapid and frequent tactical movement. Without this mobility, such vehicles will rapidly become casualties in the intensely lethal battle areas. Complex net and disruptor kits, particularly those which require careful erection at the battle site and any more than a few seconds to store following the engagement and before further movement, will probably be discarded or simply remain stowed in most engagements. There is no value in deploying such measures if they will not be effective or are too much trouble to use under fire.

The Dual-Texture Gradient (Dual-Tex) pattern was designed by members of the Department of Behavioral Sciences and Leadership, US Military Academy, to fill the need for a practical, effective camouflage pattern measure which reduces the requirement for elaborate garnish kits. The Dual-Tex pattern uses two patterns: a macropattern of large light and dark areas which is indistinguishable from the standard US Army measure at long distances, and a micropattern of higher texture which resolves on closer observation or under optical enhancement and retains its texture and color match with the background. This effect is obtained by using color "bits" grouped together on a square grid; the large light-and-dark areas of the macropattern conform to the US Army pattern, the squares form a separate pattern within the macropattern. The observer perceives the macropattern at long range, at which its effect is comparable to that of the standard measure; at closer range (approximately 2000-1500 meters) the micropattern resolves, and the concealment value of the smaller pattern continues to provide concealment after the standard pattern has begun to form a signature of its own, easily observable without extensive garnish. (See figure 1.)

The pattern was developed for exploratory test using in-house US Military Academy resources. The research was conducted in two phases from September 1976 to June 1977; the first phase was a laboratory simulation, the second was an extension of the original objectives in a field environment.

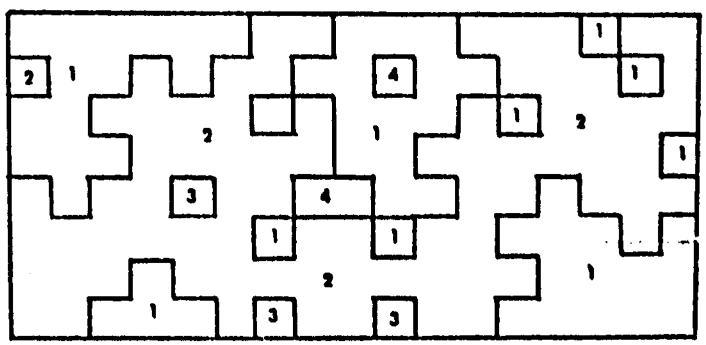


Figure 1:
Dual-Tex Pattern.
(Colors coded by number)

Phase I: Summary of Laboratory Simulation

Objective. This preliminary phase was conducted to provide a rough comparison of the Dual-Tex pattern with the standard US Army pattern measure and a control (solid green) target in a controlled environment.

Method. Subjects viewed a series of 35mm color slides, phased at decreasing ranges, of targets placed in a woodline; the pattern measure was varied by subject group; Group A viewed the US Army pattern, Group B the Dual-Tex measure, Group C viewed a solid forest green control target. The dependent variable was in each case the distance from the target upon detection and at identification of the target shape.

Approximately 260 male cadets were used as subjects; each subject was presented only one target condition. The test targets were 4' x 8' panels; the stimulus photographs were phased at decreasing range intervals of 25 feet, from 675 to 75 feet. Subjects viewed the most distant first, least distant last, so that the apparent range of observation decreased uniformly. Distance from the target was expressed for scoring purposes as a slide number from 1 to 22.

The experiment was conducted in two parts -- a summer trial and a winter trial. Photographs were prepared in an open field with summer vegetation for the first and in a similar snow-covered field for the second. In the winter trials a fourth target was added, using an adaptation of the Swedish Army Pattern.

Results and Analysis. The results of summer and winter trials are summarized below, expressed as mean number of slides by group elapsed before detection (located a target of some kind) and identification (matched the target shape to one of four alternatives printed on a comparison card):

*Summer Trial	DETECTION	IDENTIFICATION	N
Group A (US Army Pattern)	11.97	14.22	38
Group B (Dual-Tex Pattern)	15.33	17.72	38
Group C (Control)	12.68	13.97	40

Groups A and C did not differ significantly in mean detection or identification scores; Group B (Dual-Tex) differed from Groups A and C in the predicted direction and beyond the .01 level of significance.

**Winter Trial:	DETECTION	IDENTIFICATION	N
Group A (US Army Pattern)	10.95	11.59	44
Group B (Dual-Tex Pattern)	18.15	19.35	34
Group C (Swedish Pattern)	12.63	16.80	30
Group D (Control)	18.96	20.28	28

Group B differed significantly ($p < .05$) from Groups A and C, and in the predicted direction. Groups B and D, however, did not differ significantly, apparently due to special problems in the selection of the test site and the specific positions chosen for the targets.

The conclusions drawn from the initial laboratory phase were:

1. That the Dual-Texture Gradient pattern appeared to offer the potential for significant improvement over present measures in a variety of environments, and
2. That the Dual-Texture Gradient pattern required field validation.

*In the summer trial, group means were tested for significance by t-test.
**In the winter phase, group mean differences were tested by t-test; difference in means for groups A and D by Scheffé post-hoc comparison test.

Phase II: Field Evaluation

A field validation test was conducted by a research team from West Point, assisted by the US Army Human Engineering Laboratory, during May 1977 at Aberdeen Proving Ground, MD.

Objective. This phase was conducted in order to compare the standard US Army and Dual-Tex measures in a field environment, using an appropriate subject group representative of observers in a combat environment.

Method.

General. Selected subjects viewed a pattern-painted M113 target vehicle through the commander's sight of a Soviet T62 Main Battle Tank. One group viewed the target painted in the US Army pattern, the other the Dual-Tex pattern. Time to detection and correct or incorrect detection of the target type were recorded for each subject.

Test Site. The experiment was conducted near Phillips Army Airfield, Aberdeen Proving Ground, Maryland. The site consisted of an open area several kilometers in length and approximately .8 km across, oriented approximately SW to NE and bounded on the SE by a hard-surface and a dirt road. The entire area was bordered by shrubs and low hardwood forest on all sides. The target vehicle was placed near the edge of a tree line at a distance of 926 meters from the observer vehicle. The distance of 926 meters represented the best compromise of the desired distance -- 1000 -- 1200 meters -- and the location of a slight prominence at the chosen range which provided excellent observation of the target area.

Subjects. Ten aviation warrant officers from assault helicopter units stationed at various posts were used; these were experienced pilots and trained observers who were on temporary duty with the US Army Human Engineering Laboratories. In addition, twenty-eight enlisted artillery observers from the 82d Airborne Division Artillery participated in the trials. All subjects were experienced observers and were trained in vehicle recognition. The ten pilots were used in both experimental conditions; the other subjects viewed only one pattern each.

Target Preparation. The target vehicle was viewed in two conditions: the US Army pattern and the Dual-Tex pattern. Natural garnish was applied in each case to the front, commander's station and ventilator dome. The garnish was placed in these locations because the test controllers believed that the glare would create an overwhelming signature.

Test Procedures.

1. Each subject was positioned in the commander's station of the T62 observer vehicle, standing on the turret floor and facing towards the TKN3 commander's sight; the controller was seated in the gunner's position where he could observe the subject and the gunner's azimuth indicator.

2. Each subject was briefed by the controller on the use of the TKN-3 sight; the turret was deflected to the left of the target area so that the sight was aimed at a prepositioned orange panel downrange. The subject was coached by the controller in adjusting the distance between the binocular eyepieces for comfort and focusing the diopters for clear observation.

3. The subject was briefed on the procedures for the test itself:

The height choke reticle in the lower portion of the field of view of the sight was used as the reference point for identification; the range markings 8 - 30 (representing 800 to 3000 meters) were used for this purpose. The subject was instructed to search for any military target, type unspecified, which would be located somewhere between the 8 and 30 range lines of the choke reticle. After explaining the procedures, the controller asked the subject to be seated on the turret floor while the commander's sight was being re-layed in the target area.

Using the gunner's azimuth indicator, the controller laid the main gun roughly on the target. He then looked through the commander's sight to make final adjustments and insure that the lay of the sight was correct and note the reticle number which was at the center of mass of the target. This was necessary because the turret traverse was somewhat erratic on the observer tank and the commander's sight could not be aligned properly using the main turret azimuth indicator. This method proved to be an additional control measure because a different range line was used to indicate center of mass for each subject. This eliminated the chance of subjects detecting the target because they had overheard a correct detection or by having a previous subject tell them the correct range line number.

The controller then re-engaged the infrared filters and quickly reviewed the procedures and asked for any questions the subject might have. When the subject was ready to begin, he took a comfortable position at the sight; the controller removed the filter and started his timer at the same moment.

When the subject said "stop," the controller stopped the timer and asked the subject to verify the target by supplying the reticle number at center of mass. If the number was incorrect, the controller checked the sight to insure that the cupola had not slipped during the search. If the detection was incorrect, the procedure was begun again and the time restarted. If no correct detection occurred within 60 seconds, the attempt was terminated.

When and if correct detection occurred, the controller asked the subject what the target appeared to be. The identification (such as "APC," "vehicle," etc.) was noted and the subject released.

After completion of the exercise, selected subjects (the warrant officers who had viewed both pattern conditions) were individually briefed on the nature of the experiment and their subjective comments were recorded with respect to comparative effectiveness of the US Army and Dual-Tex patterns. These comments were not recorded for the other subjects, since they only saw the target in one of the two conditions and had no basis for comparison.

Results and Analysis.

Mean time-to-detection was computed for both test conditions; in cases of no detection within 60 seconds, a detection score of 60 was recorded; this was a conservative measure which allowed inclusion of all scores at the cost of inducing skewness in the sample distributions. In the sample groups, there were 9 such cases for the Dual-Tex condition and 3 for the US Army pattern; consequently, this tended to bias in favor of the US Army pattern. The experimenters accepted this bias as unavoidable.

The population parameters for observing the target patterns at a range of 926 meters were estimated. The mean score parameters estimated are listed below:

μ_{1D} - US Army Pattern Detection Mean Score.
μ_{2D} - Dual-Tex Pattern Detection Mean Score.

Observed target detection means, standard deviations and sample sizes are shown below:

	Mean (seconds)	Standard Deviation	n
US Army Pattern	22.32	20.88	23
Dual-Tex Pattern	40.35	19.74	25

Observed target detection means were t-tested; mean detection scores differed in the predicted direction beyond the .01 level of significance.

The simple difference in mean time to detect may, however, be misleading in certain practical aspects. The writers consider the likelihood of an enemy observer in a vehicle having leisure to observe one area of expected enemy activity for up to 60 seconds at 1000 meters without grave risk rather low (see discussion in paragraph below); for this reason, an observed-time hypothesis was used to show comparative effectiveness of the two patterns over time of exposure. The prediction specifies a critical span of exposure time during which the Dual-Tex pattern should demonstrate improvement over the US Army measure; common sense dictates that as exposure time approaches zero, probability of detection will likewise approach zero, and that, given sufficient exposure time, virtually all observers will detect. The rough prediction is shown below:

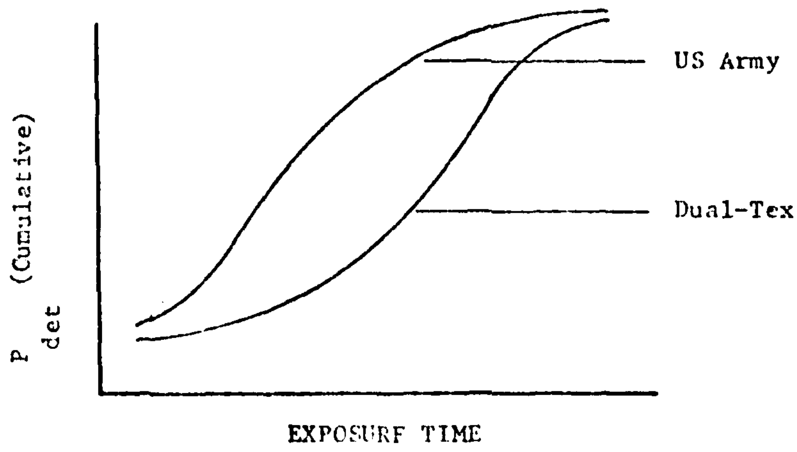


Figure 2

The observed probabilities of detection versus time are shown below:

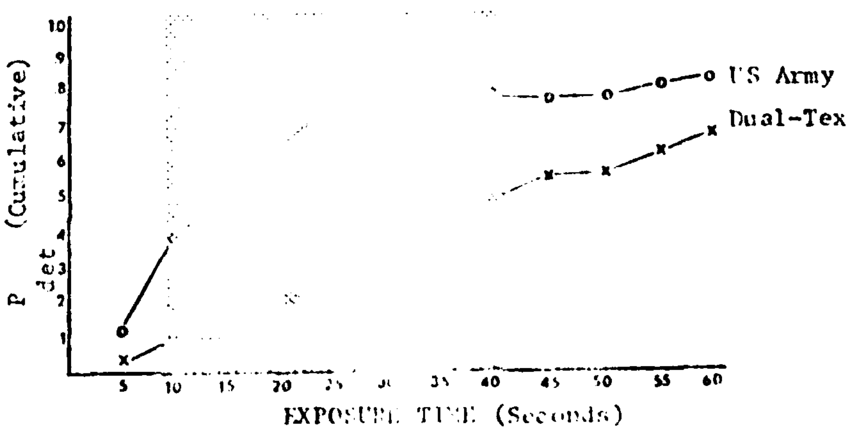


Figure 3

TABLE 1

SUMMARY OF PEARSON CHI-SQUARE TESTS OF ASSOCIATION FOR HYPOTHESES:

$$H_0 : p(A_j, B_k) = p(A_j)p(B_k)$$

$$H_1 : p(A_j, B_k) \neq p(A_j)p(B_k)$$

Time (seconds)	Chi-square Value	df	Result
5	.37	1	Accept H_0
10	4.93	1	Reject H_0 *
15	9.28	1	Reject H_0 **
20	6.68	1	Reject H_0 **
25	8.35	1	Reject H_0 **
30	5.49	1	Reject H_0 *
35	4.31	1	Reject H_0 *
40	4.53	1	Reject H_0 *
45	2.55	1	Accept H_0
50	2.55	1	Accept H_0
55	1.97	1	Accept H_0
60	2.25	1	Accept H_0

Where:

A=pattern attribute (US Army or Dual-Tex)
B=detection attribute (detection or no detection)
$p(A_j)$ = probability of occurance of event A_j

$p(B_k)$ =probability of occurance of event B_k

$p(A_j, B_k)$ = probability of occurance of the joint event (A_j, B_k)

* $p < .05$; ** $p < .01$.

Hypotheses of independence of camouflage pattern and target detection distributions at a specific point in exposure time elapsed were evaluated using the Pearson chi-square test for association. The hypotheses and results are listed at Table 1.

Discussion.

Since the Dual-Tex pattern is designed to fill a specific tactical requirement, the demonstration of higher performance without discussion of tactical impact is not of significant interest. The analysis of detection probability against exposure time, however, allows some speculation on the contribution of the experimental pattern in a modern combat environment. The shaded portion of figure 3 shows the time span in which a significant difference between Dual-Tex and the US Army pattern can be demonstrated.* This encompasses the exposure times 10 - 40 seconds; a period which probably brackets the most reasonable time required for an enemy to acquire, engage and destroy a target at the 1000-meter range tested. Hence the writers suggest that the demonstrated exposure times at which Dual-Tex offers a clear advantage are those of the most critical tactical significance. The 1000-meter range zone is generally accepted as the most likely engagement range for United States units in the European theater.

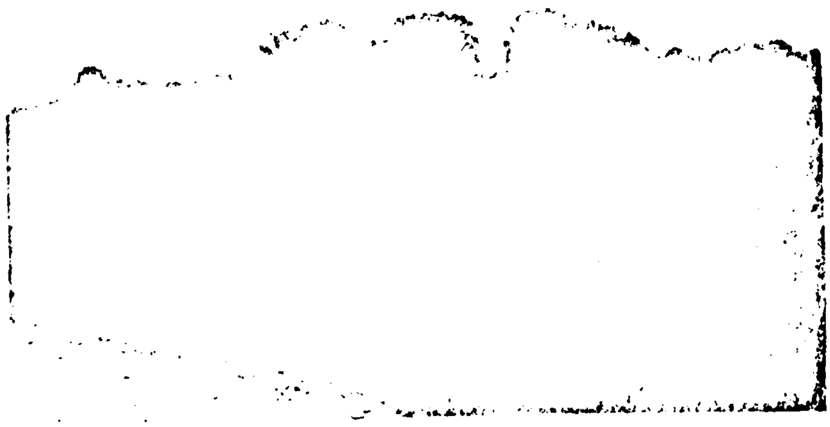
The subjective comments of the subjects who viewed both pattern conditions were uniformly favorable. These subjects were the attack helicopter pilots; since they were trained observers and gunners with considerable experience in target detection and engagement, they were considered the most credible source for qualitative critique. They were enthusiastic in their evaluation of the Dual-Tex pattern; two commented that, had they not been used to the procedure and prepared for the general target size and shape from the previous afternoon's iteration with the US Army pattern, they would not have seen the experimental pattern at all.

*The elegant consistency of the curves suggests that, had the sample size been sufficiently large, significance might have been demonstrated for the entire time range. However, the upper time span difference would, as discussion indicates, be relatively unimportant.

The writers prepared the site for test and photographed the target vehicle at various distances. At the time the photographs were taken the sun angle was most favorable for pattern effectiveness (this was at 1430, the same time that the artillery observer group which viewed the US Army pattern was tested). Under these conditions the target was almost indistinguishable despite the close range and very modest garnish. (See photographs below.) The reader will appreciate the difficulty the subjects experienced viewing the target from 926 meters, through low-magnification optics and under less favorable light conditions.

Photograph 1: US Army Pattern test vehicle.

Photograph 2: Dual-Tex Pattern test vehicle.



Photograph 3: Dual-Tex test vehicle at 75 m.

It is necessary to note at this point that the subjects' performance was to an extent at the mercy of the Soviet TKN-3 commander's sight. This is a panoramic sight of relatively low magnification; the example on the T62 used in the test did not speak well of Soviet optics in general. A particularly troublesome factor was the thickness and complexity of the stadia reticle. A US M60A1 had been positioned alongside the T62 for comparison purposes, and the reticle scribing on the US vehicle's sights was petite by comparison; the Soviet reticle actually blocked the observer's view. The writers are all familiar with the M48A3, M60A1 and M551 (and in one case the M60A2 and M60A1E3) sights, and were experienced tank commanders, and found this characteristic of the T62 sights bothersome. This is presumably considered an acceptable tradeoff given the close engagement ranges suggested by threat doctrine. The writers conclude that the crudeness of the sight also influenced the test results. However, the effect of the poor sight was uniform for both pattern conditions, and the objective of the test was to simulate enemy, not friendly, ability to detect targets. In this respect the objectives were admirably fulfilled.

Conclusions.

1. That the Dual-Tex pattern demonstrated a significant improvement in concealment effect over the standard US Army pattern under the field conditions tested.

2. That the exposure times in which significant improvement was demonstrated and the simulated engagement range match those conditions which may be tactically significant.

References. For further information consult:

O'Neill, et al. Dual-Tex: Evaluation of Dual-Texture Gradient Pattern. United States Military Academy, April 1977.

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